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DEVELOPMENT OF INTEGRATED METALLIC CONTAINER - PROJECT STATUS

Report No 84-416-K

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ABSTRACT

Several alternative designs of the integrated metallic container are being investigated in an effort to obtain an optimal integrated system for transportation, storage and disposal of used fuel from CANDU Nuclear Generating Stations. Three specific designs having thin-wall, medium and thick-walls are being proposed in more detail. A novel, simplified closure system is introduced. Some economic consideration is also presented. Many ideas presented in the report deviate from the currently pursued methodology. They are presented here as an alternative for future considerations.

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740621-113-461	825.94	January 23, 1985	84-416-K

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EXECUTIVE SUMMARY

DEVELOPMENT OF INTEGRATED METALLIC CONTAINER - PROJECT STATUS

B. Teper
Applied Structural and Solid Mechanics Section
Mechanical Research Department

The integrated metallic system is being developed to minimize handling of the used fuel from the CANDU nuclear reactors by standardizing and integrating the storage, transportation and disposal stages. The system is based on a single fuel isolation container. Once the fuel is placed in the container it will never be removed, except if reprocessing is introduced. In this case, the products of reprocessing would be returned to the containers and transported to disposal site or to a recycled fuel manufacturing facility. Several alternative container designs are being investigated, from thin wall, having 6 to 15 mm shell thickness to 150 mm thick, nearly self-shielding alternatives, to obtain an optimal system.

A mechanical closure system is proposed, which will provide a leak tight, impact resistant containment for transportation, storage and disposal of used fuel. The seal will be provided by a small weld. The closure will be readily openable and resealable for reprocessing or fuel retrieval.

The concept is technically quite simple, physically viable and economical at $2,000 for a thin-wall, 72 bundle container to $35,000 for a 96-bundle, 150 mm thick, nearly self-shielded container.

Many ideas presented in this report differ significantly from the currently pursued methodology. They are introduced here for record only, since the project is being deferred for several years. The project will not continue after January 1, 1985.

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NOMENCLATURE

AECB	- Atomic Energy Control Board
Back End of Fuel Cycle	- part of the fuel cycle from the removal of the fuel from a reactor to its final disposal
Bristol Container	- synonymous with particulate-packed, structurally-supported container built by Bristol Aerospace Limited
Container	- a receptacle used for burying nuclear fuel waste
Disposal Facility	- a facility used to emplace or discharge waste materials with no intention of retrieval (for example an underground disposal vault and its supporting facilities)
Disposal System	- a disposal facility and the transportation facilities needed to bring nuclear fuel wastes from the interim storage sites
IAEA	- International Atomic Energy Agency
Ontario Hydro Container	- synonymous with Thin-Wall Particulate-Packed Container
OHRD	- Ontario Hydro Research Division
TWPP Container	- Thin-Wall, Particulate-Packed Container
Used Fuel	- Fuel extracted from a reactor at an end of its useful cycle, and containing significant amounts of plutonium and other fission products in access of 0.25 mCi

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To Mr. H.N. Isaac
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DEVELOPMENT OF INTEGRATED METALLIC CONTAINER - PROJECT STATUS

1.0 INTRODUCTION

The concept of the Integrated Metallic Container (IMC) was introduced under the name of "Overpack Container", as a primary disposal container, in September 1980. The concept is now well developed and its benefits and drawbacks are well understood. Due to the recent evaluation of the priorities in the Nuclear Waste Management Program, further development of the concept is being deferred for several years. This report discusses the current state of project development. Many ideas presented here differ significantly from the currently pursued methodology. They are introduced as an alternative to the present concepts, for future reference. In its present form, the IMC is designed to form the "basic package" for use in several phases of the integration process of the irradiated (used) fuel management (IFM) cycle:

a) storage
b) transportation
c) immobilization and disposal
d) possible reprocessing

The container is being considered for both full and partial integration as defined by N.C. Burnett/1/.

"In full integration, the same HOLDING, CONTAINING and SHIELDING devices are present throughout all (four) IFM phases, although supplementary protection may also be required in some phases to meet specific needs. This supplementary protection is known as an overpack".

"In partial integration, the minimum requirement is that the "HOLDER" must be common in at least (two) phases. The most likely variations involve the use of containers and/or shields, being common to more than one phase".

The conceptual design went through several iterations, as seen in references 2 and 3. We are still evaluating several alternative designs to ensure their good performance, manufacturing viability and economy. Several alternative designs, currently under consideration are presented in this report. The design cannot be finalized because several external guidelines have not been decided upon, as discussed in section 4.4.

Three basic design concepts are being evaluated:

- A thin-wall 6 mm to 19 mm container will only contain the used fuel and prevent the leakage of the contaminated, inside gases to the outside. A set of overpacks will be required during various stages of the back-end of the fuel cycle.

- A medium-thickness container (40 to 60 mm) will contain the fuel, prevent leakage and will serve as the structural member for disposal.

- A thick-wall container (100 to 150 mm), beside the above mentioned functions, will also serve as the primary containment for transportation (capable of withstanding postulated accident conditions) and possibly as a corrosion resistive shell for disposal.

The report describes the latest developments in the design, feasibility assessment for various applications, performance and economy of the various types of containers. It should be noted however, that comprehensive system viability of the integrated metallic system can only be demonstrated in a comprehensive prototype test program, particularly to show its compliance with transportation requirements (eg, drop tests).

2.0 DESIGN REQUIREMENTS

The proposed container designs are intended for integration of several stages in used fuel handling process into one continuous scenario where fuel handling is minimized. Each of the stages poses different requirements, all of which must be satisfied by the Integrated Container (IC).

2.1 Transportation

Fuel immobilized inside the container will be transported to various, off-site facilities, such as: extended storage, reprocessing facilities or final disposal site. The container could be transported by truck, railway car, barge or their combination. Each mode of transportation must satisfy the requirements imposed by IAEA and by appropriate Canadian authorities (AECB). These requirements include:

1. Safety precautions during transportation:

   a) radiation shielding
   b) leakage protection
   c) size and weight restriction

2. Postulated accident conditions including:

   a) a free drop from 9 m height onto an unyielding surface,

   b) a drop on a blunt pin 15 cm diameter from 100 cm height,

   c) an exposure to a 30 minute fire at 800°C, following the drops,

   d) immersion in water for 8 hours at 150 kPa pressure without violating the structural integrity of the container or allowing for excessive gas leakage or surface radiation.

2.2 Storage

The IM containers are being proposed for use in the Dry Storage (DS) facility. The facility could be in form of a large convective vault/4/ capable of accommodating several hundreds of containers. Alternatively, smaller, stationary concrete silos could be used to accommodate a few containers per silo.

The DS imposes the following requirements on the containers:

1. Good heat transfer to the outside surface to minimize the temperature of used fuel.

2. An adequate strength to allow stacking of the containers several layers high.

3. Low corrosion in the disposal environment - satisfied for most metals.

4. Easy handling arrangement for placement and retrieval.

5. Anticipated duration of storage: for example 50 years.

2.3 Disposal

At the disposal site, the IM container will be overpacked with a corrosion protective shell if required and placed in a disposal vault. Corrosion protection can take several forms, as discussed in section 7.3.

The container must be designed to meet the following criteria:

1. the container cannot have any perforations due to corrosion for 500 years;

2. the container must be able to support an external pressure of 10 MPa in the event the repository is flooded with a 1000 m head of water;

3. the container will operate in temperatures of up to 150°C;

4. the container should not contain materials known to increase mobility of radionuclides.

5. retrievability is not required at present, however, it provides several benefits including additional safety features;

The medium and thick-wall containers are given preference here because they are self-supporting. The thin-wall container may require a stronger and more expensive structural and corrosion protective overpacks.

AECL is responsible for the disposal of used fuel. Ontario Hydro participates in the program under the Technical Assistance Program (TAP) Agreement. The application of the container to disposal of fuel will be given a separate consideration under the TAP starting in January 1985.

2.4 Reprocessing

If reprocessing is decided upon in the Canadian program, the following container features are required to facilitate it:

1. The container should be reopenable and resealable up to two times, remotely and efficiently;

2. The container should provide structural boundary for casting of hot, vitrified waste.

3.0 THIN-WALL CONTAINER

A thin-wall container provides for a low cost, simple technologically concept for immobilization of fuel. Two sizes are currently being considered, containing 72 and 96 fuel bundles/5/ in four layers. A conceptual drawing of the container is shown in Figure 1. A layout of bundles is illustrated in Figure 2. The cylindrical shells of both containers could be made of standard pipes. Both containers would have a wall thickness of

about 6 to 17.5 mm (1/4 to 11/16 in). A large thickness top plate is proposed to allow for an integral lifting device in the form shown in Figure 3. This could be an alternative lifting system to an electromagnetic pick-up arrangement.

4.0 MEDIUM AND THICK-WALL CONTAINER DESIGNS

4.1 Concept Description

In the opinion of the writer, a large thickness, integrated metallic container provides the most suitable means for integration. Such a container is believed to be able to combine all currently postulated stages of the back-end of the nuclear fuel management: dry storage, transportation and disposal. The scenario is illustrated in Figure 4. The fuel will be placed in the container at the water bay storage facilities or at the extended storage facility. Once the fuel is sealed inside the container, it will not be removed, except for reprocessing, if required. The container's external surface will be decontaminated after sealing.

Two alternative wall thickness ranges are considered: 40 to 60 mm and 100 to 150 mm. The 50 mm thick container has an adequate thickness for disposal, however it would require expensive, high thickness, high integrity and fully radiation shielded overpack for transportation and a second overpack for corrosion protection for disposal. The thicker container will have an adequate thickness to:

- satisfy the IAEA and the Canadian transportation requirements for accident condition only (an additional low strength transportation overpack may be required for radiation shielding);
- provide the required strength for the postulated impact loads during transportation accident;
- provide the required structural strength plus an adequate corrosion allowance for disposal in a repository with mild environment.

The preliminary evaluation indicates that the medium thickness container is more economical if a separate corrosion protective shell is required. It might be possible to eliminate the corrosion protective shell if 100 mm corrosion allowance is adequate, then the 150 mm thick steel shell can be used without an additional corrosion protection.

The proposed IMC consists of three parts:

(a) outer corrosion protective shell,
(b) thick container, made of mild steel,
(c) steel basket.

The protective shell is only used when a long term corrosion barrier is required. The shell could be made of titanium, copper, concrete or other inert or thick material. A titanium outer shell would be made of 3.56 mm or thicker plate. The flat plate closures have the same thickness and are diffusion bonded to the cylindrical shell, as shown in Figure 5.

The copper and concrete corrosion barriers could be of significantly larger thickness, but at lower cost than titanium.

The mild steel canister is the structural member. Its cylindrical shell is 40 mm to 150 mm thick. In one of the proposed designs, the outside surface has a slope of about 0.3°. This slope provides us with a 10.4 mm (0.41 in) radial clearance for inserting the steel canister into the protective shell. The protective shell will have a similar 0.3° slope to ensure good fit.

Dimensions and configurations of several alternative designs are illustrated in Figure 5.

4.2 Multi-Layer Design

The large thicknesses proposed for the containers can be obtained by several methods:

- multi-layer arrangement obtained by fitting; several pipes coaxially by thermal expansion;
- using various casting techniques;
- rolled plates, seam welded;
- standard seamless pipes.

The multi-layer arrangement is economical, however, it has several disadvantages. To obtain the large thickness, in excess of 35 mm, more than two pipes would be required, because the largest available thickness of pipes larger than 24 inches diameter is 1 inch. Because of the pipe manufacturing tolerances, the largest pipe thickness of 17.5 mm is recommended. In this arrangement the theoretical radial clearance between pipes would be about 8 mm. The pipes would not support each other without large, plastic deformations.

4.3 Single Layer Design

Several alternative container designs are considered. For example, some advantages could be derived by reducing the diameter of the basket. Figure 6 shows a 530 mm diameter basket capable of holding 96 bundles in 6 layers. This basket does not provide for high density of packing (space utilization), however, it will allow for the use of 24 in, sch. 100 seamless pipe, having wall thickness of 40.0 mm. A corrosion protective shell can be introduced for this container using various cladding techniques, as discussed in reference 8.

Seam welding of a rolled plate is very expensive, laborious, and the radius of rolling is limited for a given thickness. This method has not been investigated in any detail because of its many limitations.

The preliminary investigations indicate that casting is the most economical, accurate and versatile method which should provide adequate quality containers. The quality of casting should be reviewed for various casting techniques. Centrifugal casting of the cylindrical shell with the bottom plate welded in, appears to be the most effective. Cost of such castings would be about three times the price of steel plate of equal weight. Die-casting might also be viable. Sand casting is the most reliable and it allows for casting the bottom plate as an integral part. However, this method could be expensive and slow for the required large volume of containers.

4.4 Alternative Designs

The Integrated Metallic Container design cannot be finalized because decision has not been made regarding:

- preferred bundle capacity of a container (72, 96 or other);
- corrosiveness of the repository environment;
- preferred size of the container - small diameter and tall or short but stout;
- type of extended, dry storage facilities: large vaults, smaller silos or small, shorter term fuel consolidation facilities;
- preferred type of transportation and transportation distances involved;
- preferred corrosion protection system;
- many other, less significant factors which affect the container design.

These factors of the design have not been finalized and they are outside the designer's jurisdiction.

Thus the current effort is concentrated around concept feasibility. Although 50 mm and 150 mm thick, 96 bundle, cast steel containers will be used as two "reference" designs for the following sections, many other container configurations are being considered, some of them were introduced previously.

Besides different dimensions, the alternative designs involve different methods of corrosion protection, manufacturing techniques and even changes in the container usage, as briefly discussed in previous sections. Several alternative closure systems are being considered from full penetration, welded systems to weld free, press-in arrangements.

5.0 CLOSURE SYSTEM

A novel closure system is being investigated, which can facilitate good closure with possibly only a small seal weld. The closure is currently being tested.

Several different closure systems are being considered, from full penetration weld to mechanical, seal welded. The full penetration weld of the required thickness is difficult to achieve in a remote environment. Its inspection and repair is nearly impossible. A mechanical closure system is proposed to improve the ease of assembly, inspection and resealability. An example of the closure system is shown in Figure 7. The small, 6° taper provides for easy placement of the lid. A compressive force of about 3×10^6 N (750,000 lbs) will be required for the self-locking closure. The closure is expected to release at an internal pressure of about 0.7 MPa or an axial force of 1×10^6 N. The lid can be removed by induction (high rate) heating of the cylinder rim. The forces required for closure and opening are approximate and are based on the preliminary results of our closure test program using 6" pipes.

The leak rate test forms a part of the test program. The preliminary indications are that the leak rate is quite low, however, it might exceed the IAEA allowed radionuclides release rate for transportation. A plate 12 mm thick welded to the cylinder can provide a good seal. This weld need not be inspected or stress relieved as it is not a structural weld. The plate can be easily cut off and replaced should we decide to open and reclose the container.

6.0 CONTAINER HANDLING SYSTEM

A provision is being made for handling of the containers in both, horizontal and vertical positions. Horizontal position

handling will be required during loading of the container with fuel and during transportation. Placement in storage or disposal will require vertical handling. Vertical handling is facilitated by the pin in the top closure, shown in Figure 3. The removable straps shown in Figure 8 are designed for horizontal handling. The straps could be installed before fuel is inserted and remotely removed when no longer needed. Large, electromagnetic devices could provide a more reliable, economical and practical means or horizontal and vertical handling of the thick-wall containers.

Back-up lifting devices could be provided by high friction clamping devices shown conceptually in Figure 9.

7.0 THICK-WALL CONTAINER APPLICATIONS

7.1 Transportation

7.1.1 Shipping Arrangement

The responsibility for fuel transportation lies with the Nuclear Materials Management Department (NMMD). Several ideas about transportation of IMC are outlined here for further discussion.The IMC is designed for transportation by truck, rail car or barge. Each mode of transportation poses different constraints pertaining to:

a) Size of shipment: its width, length and height;
b) Weight of shipment;
c) Weight distribution on the vehicle.

These constraints determine the number of containers per shipment and size of the overpack.

Road transportation system is designed to allow for the use of popular size tractor-trailer arrangements. This will allow for easy equipment replacements if equipment failure occurs while in transit. Gross cargo weight (excluding the weight of the vehicle) should not exceed 420,000 N (95,000 lbs), for a five axle, 11.8 m (465 in) base length vehicle. If we assume that we require 203 mm (8 in) thick total steel radiation barrier for transportation, we could transport 2 to 3 water-storage modules per shipment, as shown in Table II. Larger quantities of containers could be transported using special tractors and seven axle trailers. If larger thickness of transportation overpack is required by NMMD, we can reduce the number of containers per shipment, or preferably use the seven axle trailers, having capacity of 530 kN (120,000 lbs) of cargo. The basic information on the transportation arrangements are shown in Table II, including shipping weights, dimensions and fuel capacity.

Rail transportation allows for larger pay loads and longer loads. Thus, if mixed road-rail transportation is postulated, each rail car can transport two to three road overpacks. Alternatively, much larger overpacks could be designed. Similarly, barge transportation offers large capacity and size, allowing for many different transportation arrangements and overpack designs. It is difficult to propose any specific lay-outs until more specific transportation requirements are known.

7.1.2 Effect of Drop

The regulations governing the transport of radioactive materials postulate several accidents, consisting of a drop on a flat, unyielding surface and on a pin, as discussed in Section 2.1 and in /1/.

The effect of such drops on our transportation system using IMC has not been analyzed or tested yet. Past experience shows, however, that thick cylindrical shells and small, thick flat plates can withstand the postulated impact without excessive deformations or failures. The containers having 150 mm wall thickness are expected to be adequate, if their temperature is maintained above Nil Ductility Transition Temperature plus 20°C as required by ASME Code to ensure that the container shell is ductile. Adequate ductility should be ensured by the heat generated by the bundles combined with the insulating properties of the overpack. The overpack will be destroyed in case of the postulated accident. It will, however absorb significant amount of the impact energy. The overpack will be reusable and inexpensive.

The overpacks will have to withstand the impact for containers having thickness smaller than 125 mm. Overpacks for thinner containers should be made of stainless steel or other, highly ductile material and should be equipped with impact absorbers. Such overpacks are very expensive, however they are reusable.

7.1.3 Effect of Fire

The transportation system does not contain any flamable materials to further fuel the 30 minutes postulated fire at 800°C. The shell of a container is expected to heat up fully during the 30 minutes. The air and bundles inside will remain at relatively low temperature, due to the low, largely convective heat transfer. The preliminary study indicates that the air temperature inside the container will not exceed 350°C. Assuming dry air, the pressure inside should not exceed 2.5 atmospheres. The 12 mm (1/2 in) seal welded plate is adequate to support this pressure. The containers will survive the fire without significant damage.

7.2 Storage

The storage aspect has been adequately covered in section 2.2. All of the discussed designs meet the postulated requirements. The design of the container for storage will be advanced further through discussions with the Irradiated Fuel Storage Unit of NMMD.

7.3 Disposal

The IM concept was originally introduced as an alternative disposal container to be integrated into the Technical Assistance Program (TAP) to AECL. Many of its features were optimized for disposal.

The required shell thickness for the postulated external pressure of 10 MPa in the disposal facility is 41 mm for the 72 bundle containers and 50 mm for 96 bundle containers as required by Section III of the ASME Pressure Vessel Code. The flat plate closures need to be 88 and 100 mm thick respectively to support this pressure. These thicknesses form base for the dimensions of the medium thickness (50 mm) containers in Figure 5.

If the environment in the repository is quite mild, the rate of carbon steel corrosion would be low, and it is expected to decline with time, as illustrated in Figure 10. It is anticipated that a 75 mm corrosion allowance might be adequate for 500 years. This thickness is provided in the largest thickness containers. Data demonstrating validity of this claim is currently being accumulated in various foreign programs, including US. If the repository environment is more aggressive then the external shell could be tapered for easy overpacking with similarly tapered, corrosion protective shell/2/. A grade 2, commercially pure, titanium shell having thickness of up to 3.56 mm is the most likely protective shell, presently being considered. Such a protective shell could be used on the 50 mm thick containers.

Alternatively, steel corrosion can be inhibited by modifying the repository environment. For example, a borehole could be lined with a concrete precast, before the container is inserted (see Figure 11), to form a high pH environment. High pH, however facilitates easy dissolution of radionuclides. This could be partly compensated for by introducing radionuclides retaining substances, such as phosphates or by carefully controlling the pH value by using special cements.

7.4 Reprocessing

It has been previously shown that the proposed containers can be easily reopened and that they have an adequate strength for solidification (casting) of vitrified wastes, facilitating their use for reprocessing.

Only few of the containers used for immobilization of used bundles will be required for solidification of the vitrified wastes from reprocessing. The remaining containers can be recycled following some decontamination. The recycling process would consist of the following stages:

- shipping of the reusable products of reprocessing to the fuel manufacturing facilities.
- shipping of new fuel bundles to a station.
- removal of used, 10 year old or older fuel from a station.

8.0 ECONOMIC CONSIDERATION

The IM concept has been shown to be a technically viable and relatively simple system to develop. Its flexibility allows for easy accommodation of the many changes being proposed to the nuclear waste management system in the conceptualization of the system.

Besides being technically advantageous the concept is economically beneficial. Our preliminary investigation shows that the containers including baskets could be manufactured by casting at about three times the equivalent cost of steel plate of about $3.00/kg. Price of the containers ranges from about $2000 for the thin-wall, 72 bundle container to $35,000 for the 150 mm thick, 96 bundle container. An approximate cost for large volume production of all proposed containers including baskets is shown in Table III.

9.0 CONCLUSION

The Integrated Metallic Container design proposed here will not be pursued after January 1, 1985, as the project is being deferred. Many ideas presented above are introduced for completeness of the IMC project description and for future reference only.

Several alternative designs for the Integrated Metallic Container (IMC) have been presented. The containers are intended for immobilization of used fuel bundles from CANDU nuclear power stations for: transportation, storage and disposal of the fuel. The use of container encompasses also the handling of the high level radioactive wastes from reprocessing, should it be introduced into the Canadian Nuclear Waste Management Program.

The management of high level radioactive wastes, including used fuel bundles, using IMC can be shown to be economical and technically viable. The containers can be designed and manufactured with only small amounts of research and developmental activities.

The IMC concept is very flexible allowing for easy implementation of many changes which might be introduced to the nuclear waste management program in the future.

It is recommended that the concept should be pursued further to its successful completion, including demonstration. Special emphasis should be placed on the development of the proposed closure system and evaluation of corrosion in steel under repository environment.

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TABLE I

WEIGHT OF CONTAINERS

Type of Container	Number of Bundles	Weight of Components (kN)				Total Weight	
		Bundles	Basket	Shell	Corrosion Overpack	kN	Tons
Thin-Wall	72	16.7	0.3	5.9	*	23.5	2.4
Thin-Wall	96	21.3	1.1	7.1	*	29.5	3.0
Thick-Wall (50 mm)	72	16.7	0.9	21.6	0.6	39.2	4.0
Thick-Wall (50 mm)	96	21.3	1.1	24.7	0.7	47.8	4.9
150 mm	72	16.7	0.9	75.0	0.6	93.2	3.5
150 mm	96	21.3	1.1	96.9	0.7	120.0	12.3

* Several overpacks may be required and they form a separate project.

TABLE II
ROAD TRANSPORTATION DATA

Type of Containers Shipped	Number of Bundles per Container	Size of Shipment (Number Shipped)			Weight of Shipment (kN)			Size of Transportation Overpack (m)		
		Containers	Bundles	Equiv to Modules	Containers	Overpack	Total	Length L	Width W	Height h
Thin-Wall	72	4	288	3	94.0	314.0	408	2.88	2.40	1.05
Thin-Wall	96	3	288	3	88.5	276.5	365	2.55	2.40	1.11
50 mm Shell	72	4	288	3	157.0	256.0	413	3.00	2.50	1.00
50 mm Shell	96	3	288	3	143.4	250.0	393	2.72	2.50	1.11
150 mm Shell	72	3	216	2.25	280.0	132.0	412	2.73	2.45	1.00
150 mm Shell	96	2	192	2	240.0	155.0	395	2.11	2.45	1.11

All dimensions are in metres and are largest postulated.

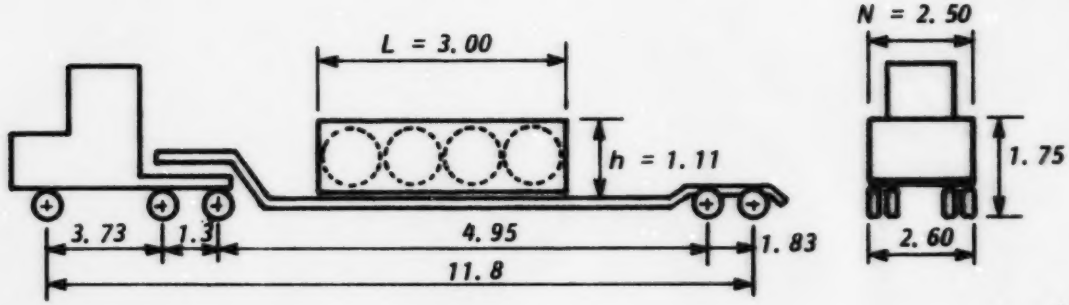


TABLE III

COST OF CONTAINERS

(For Large-Scale Manufacturing)

Type of Container	Number of Bundles	Container Weight (kN)*	Estimated Price ('84 $)*
Thin-Wall**	72	6. 8	2 000
Thin-Wall**	96	8. 2	2 500
50 mm-Wall	72	22. 5	9 000
50 mm-Wall	96	25. 8	11 000
150 mm-Wall	72	75. 9	27 500
150 mm-Wall	96	98. 0	35 000

* Basket is included

** Made of standard pipe

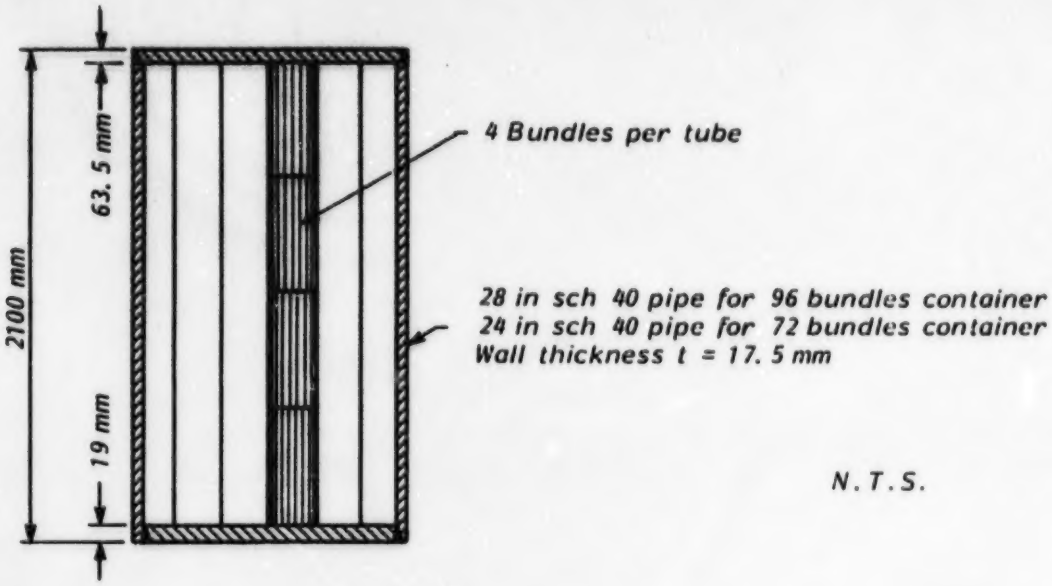
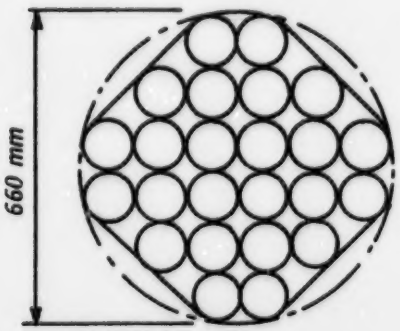
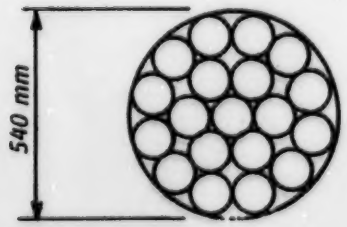

63.5 mm
2100 mm
19 mm
4 Bundles per tube
28 in sch 40 pipe for 96 bundles container
24 in sch 40 pipe for 72 bundles container
Wall thickness t = 17.5 mm
N.T.S.

FIGURE 1
CONCEPTUAL LAYOUT OF THIN-WALL CONTAINER

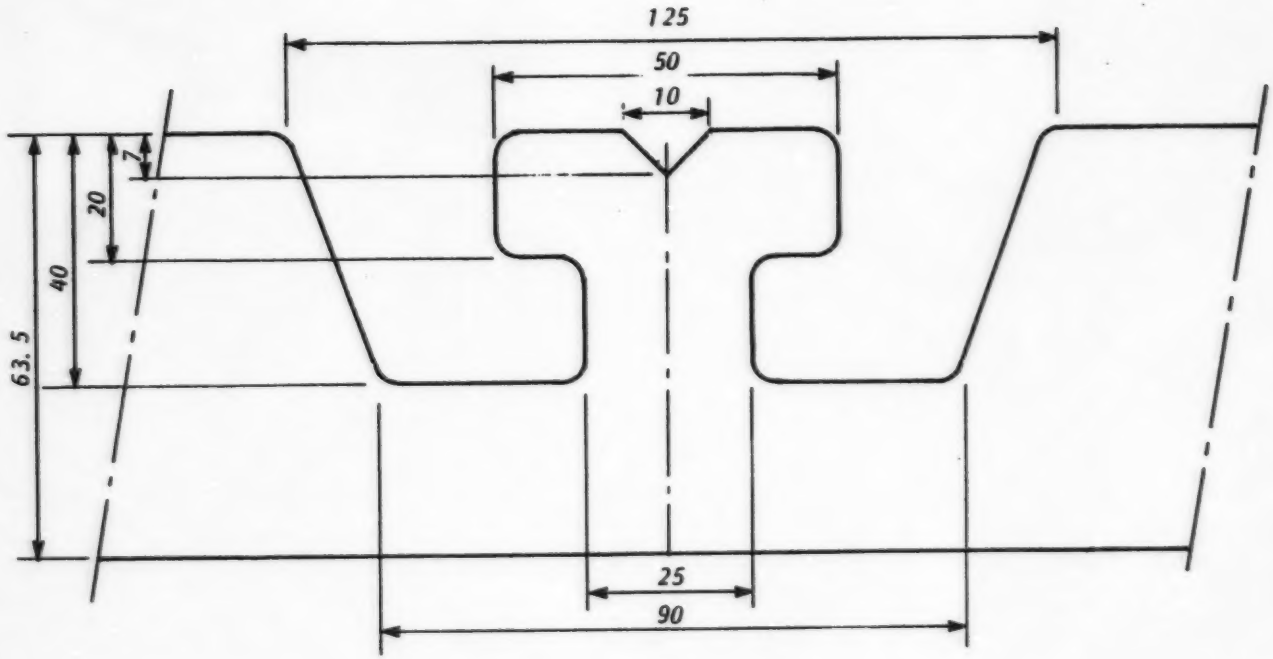


(a) Arrangement for 96 bundle container



(b) Arrangement for 72 bundle container

FIGURE 2
LAYOUT OF BUNDLES IN IMC (4 LAYER ARRANGEMENT)



Scale 1:1

Notes:

1. *All dimensions are in mm*
2. *All radii 10 mm or larger*
3. *All tolerances* $^{+2}_{-0}$

FIGURE 3

LIFTING ARRANGEMENT FOR THIN-WALL CONTAINER

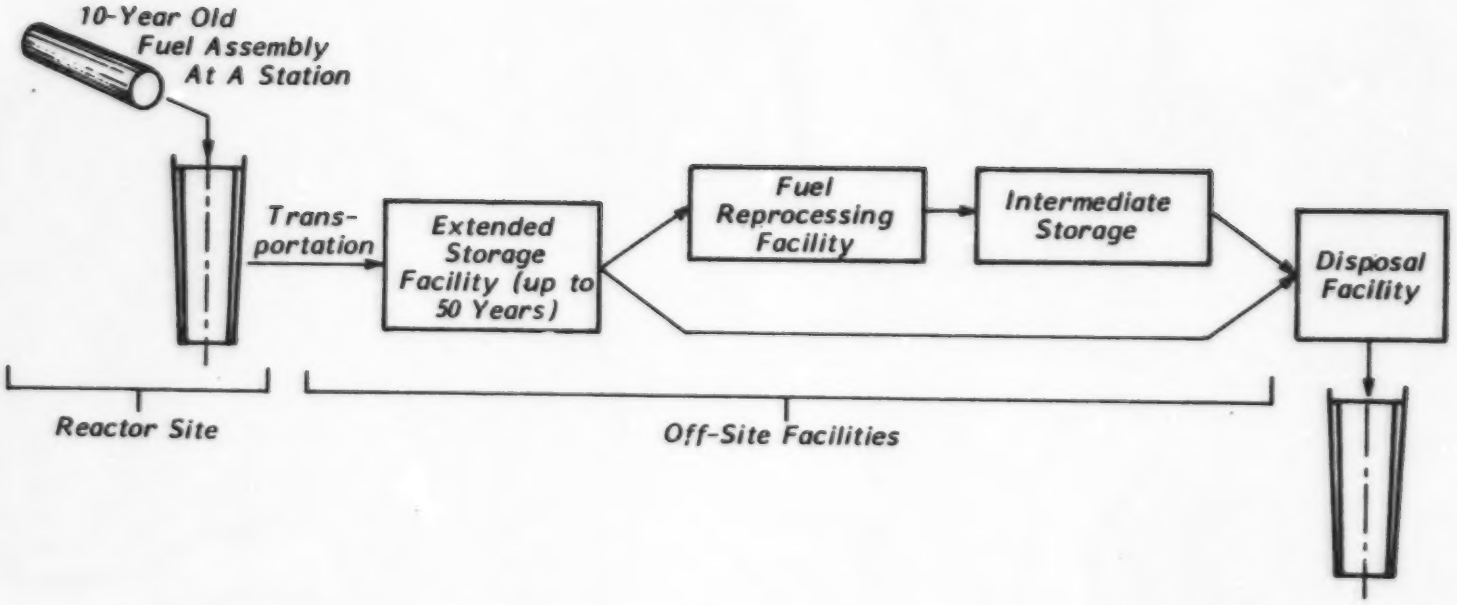


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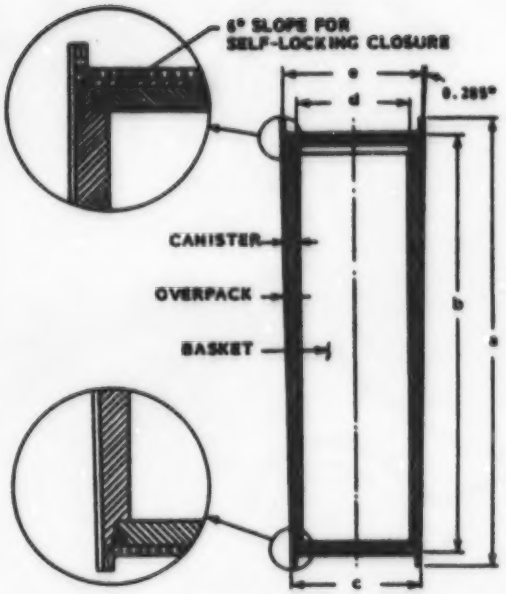
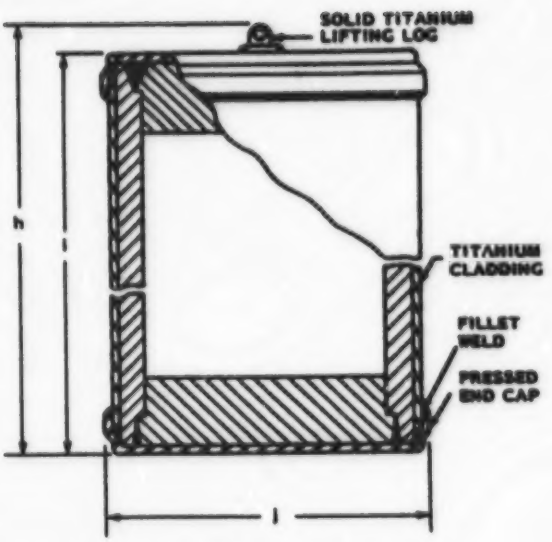
FIGURE 4
SCHEMATIC OF THE APPLICATION OF THE CONTAINER



a) CONICAL SHAPED CONTAINER



b) CLADDED CONTAINER

CONTAINER SIZES

TYPE OF CONTAINER*	NUMBER OF BUNDLES	CONTAINER DIMENSIONS (mm)							
		a	b	c	d	e	h	i	j
THIN-WALL**	72	2215	2105	620	540	620	2150	2070	***
THIN-WALL**	96	2215	2105	720	660	720	2150	2070	***
50 mm SHELL	72	2285	2175	650	540	670	2150	2070	657
50 mm SHELL	96	2285	2175	775	660	795	2150	2070	657
150 mm SHELL**	72	2350	2240	850	540	870	2150	2070	***
150 mm SHELL**	96	2350	2240	975	660	995	2150	2070	***
6-LAYER **	96	3260	3150	620	530	620	3125	3050	627

* CONTAINERS HAVE FOUR LAYERS OF BUNDLES EXCEPT AS STATED.

** SHELL IS NOT TAPERED.

*** THESE CONTAINERS ARE NOT INTENDED FOR CLADDING.

FIGURE 5

APPROXIMATE CONTAINER SIZES AND LAYOUTS

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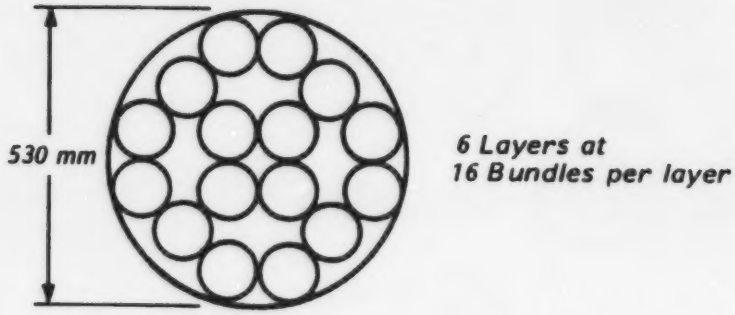

FIGURE 6
ALTERNATIVE BASKET FOR 96 BUNDLES

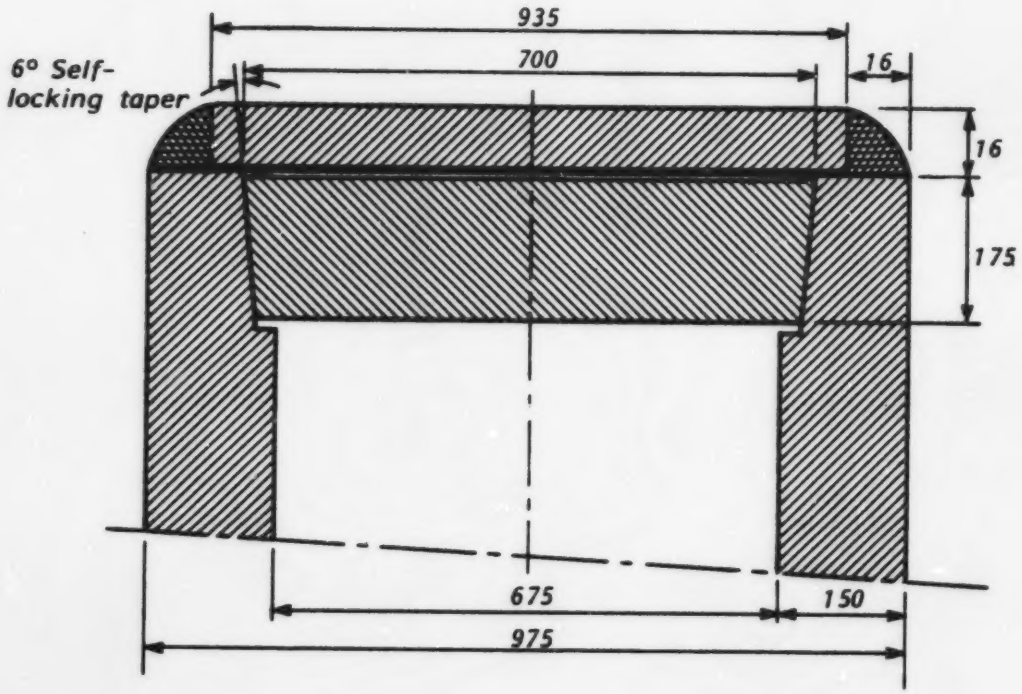

FIGURE 7
EXAMPLE OF MECHANICAL CLOSURE

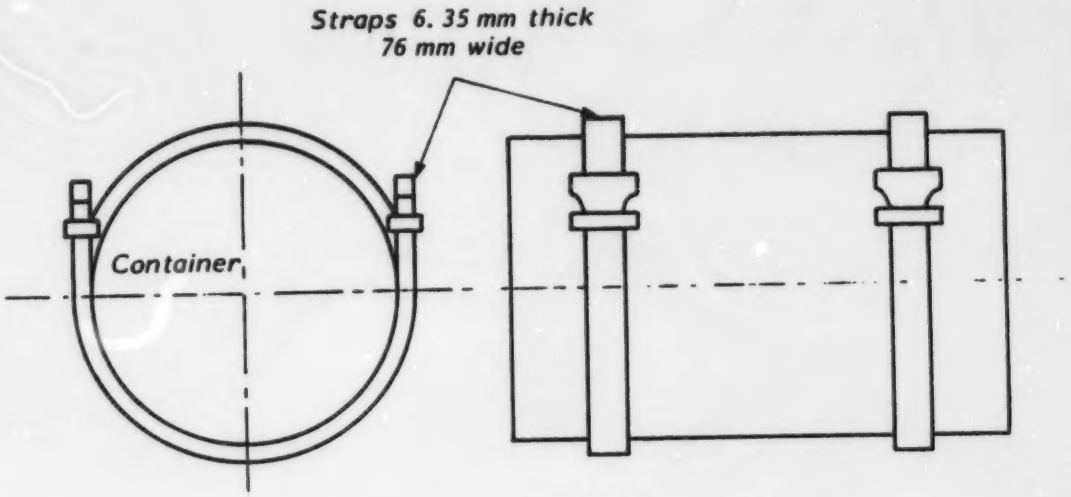

FIGURE 8
STRAPS FOR HORIZONTAL HANDLING (CONCEPT ONLY)

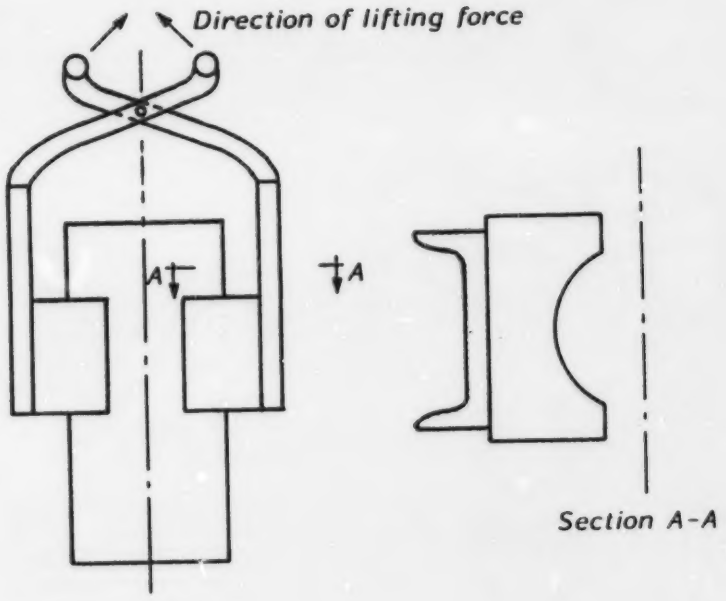

FIGURE 9
BACK-UP LIFTING ARRANGEMENT

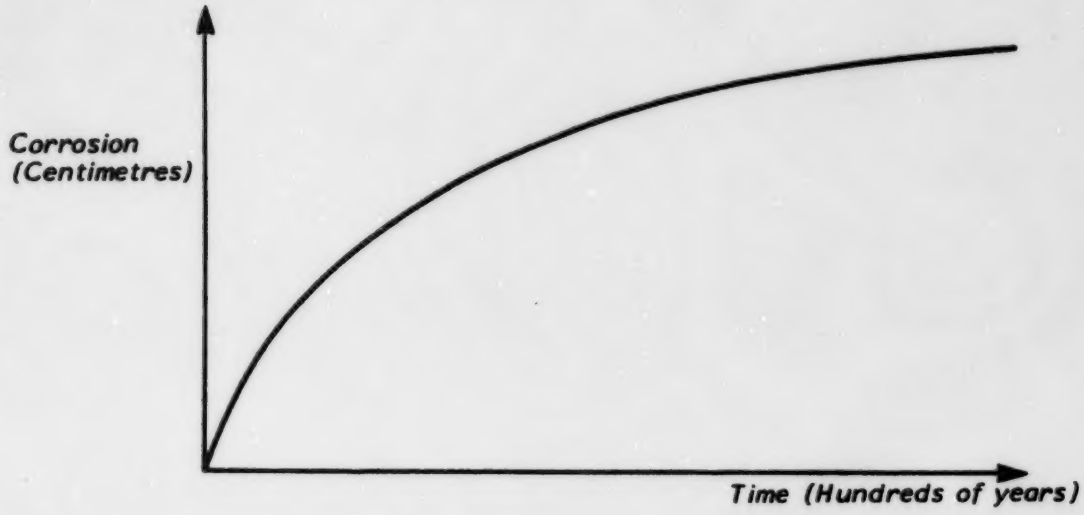

FIGURE 10
RATE OF CORROSION OF CARBON STEEL

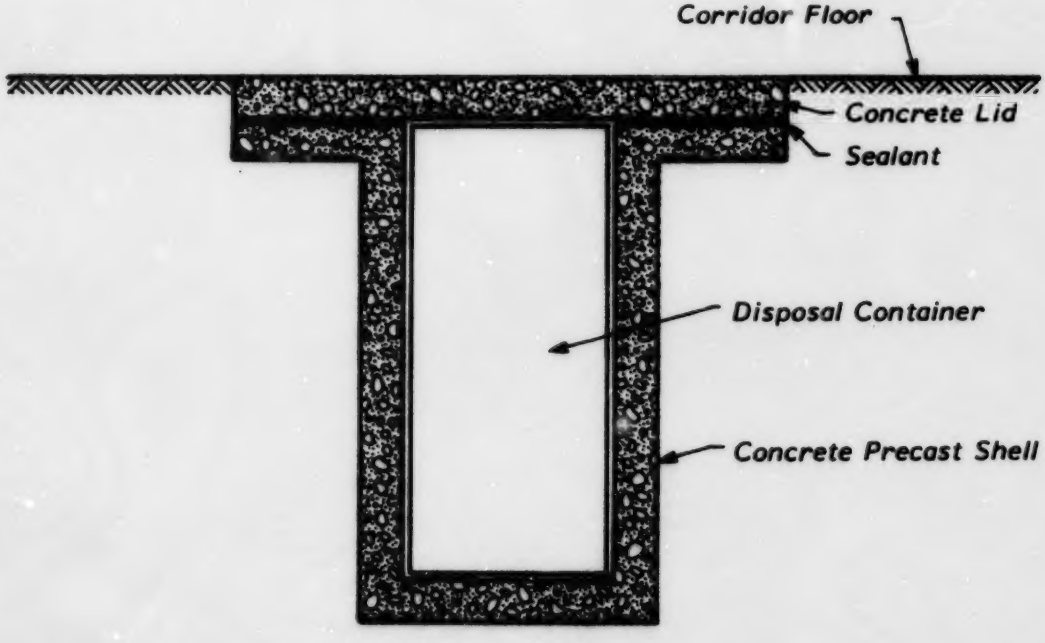

FIGURE 11
CONCRETE OVERPACK USED TO INHIBIT CORROSION